Mini UAV Sensor Suites

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CECOM Bottom Line: THE SOLDIER

Outline

- **Near Term**
  - ➢ **Developing Requirements**
  - ➢ **Mini UAVs and their Payload Capacity**
  - ➢ **Challenges**
  - ➢ **Sensors**
  - ➢ **Experiments**

- **Payload Extensions**
  - ➢ **Aided Target Recognition**
  - ➢ **Airborne Video Surveillance**
  - ➢ **Objective Mini UAVs**

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Mini-UAV Sensors and Requirements

Sensor Technology Options

- **Uncooled IR Þ 8-12 µm Bolometer**
    - + Long Wave - Most Conditions
    - + Good Sensitivity
    - + Cost effective
    - + Low Power
    - - Long Dwell Time
    - - Poor for Dynamic Scenes
    - - Large optics (weight & volume)
- **SWIR Þ 1.0-1.5-2.5 µm TE Cooled**
    - + Good for Dynamic Scenes
    - + Camouflage penetration
    - + Low Power
    - - Energy Starved Under Some Conditions
- **E-O Þ Visible CCD**
    - + Very Small
    - + Very Light Weight
    - + Lowest cost
    - - Daytime Use Only
- **Acoustic**
    - + Long Range Target Cueing
    - - Requires Quiet Operation

Mini UAV System Requirements Proposed

- Operational Range up to 10 Km
- Day & Night sensors
- Silent Operation
- 2hr. Duration
- Active Controls for Stable Image
- 1000 FT AGL
- Low Power - Line of Sight
- Communications
- Single Man Portable, Deploy,
- Automated Launch, and Recover
- GPS Flight Route Control
- Automatic and Manual Search Patterns
- 26"-36" Wingspan
- 600ft Recognition Range
- Standard RS170 Video display

Downlink Display

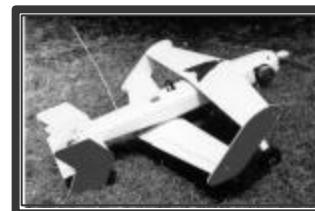**Provides Over the Hill View of the Battlefield**

Mini-UAV Technologies Under Development

	Mini Air Vehicles (DARPA)	Pointer (NVESD/USMC)	Back Pack (NVESD FY00 Congressional Plus Up)	Cypher (NVESD/USMC)
Wingspan	36 inches	9 ft	36 inches	56-72 inches
Max TO Weight	2.25 lbs	12.5 lbs	25 lbs	200 lbs
Payload Weight	0.56 lbs (9 oz)	2.0 lbs	8 lbs	50 lbs
Sensor	CCD 240 x 320 LWIR (Growth)	120 x 160 CCD or LWIR 240 x 320 LWIR (Growth) w/Acoustics(Growth)	CCD 240 x 320 LWIR (Growth)	256 x 256 InSb FLIR 640 x 480(Growth) Drop Sensors (Growth)
Fuel	Battery	Battery	Oil/Alcohol or MOGAS	MOGAS

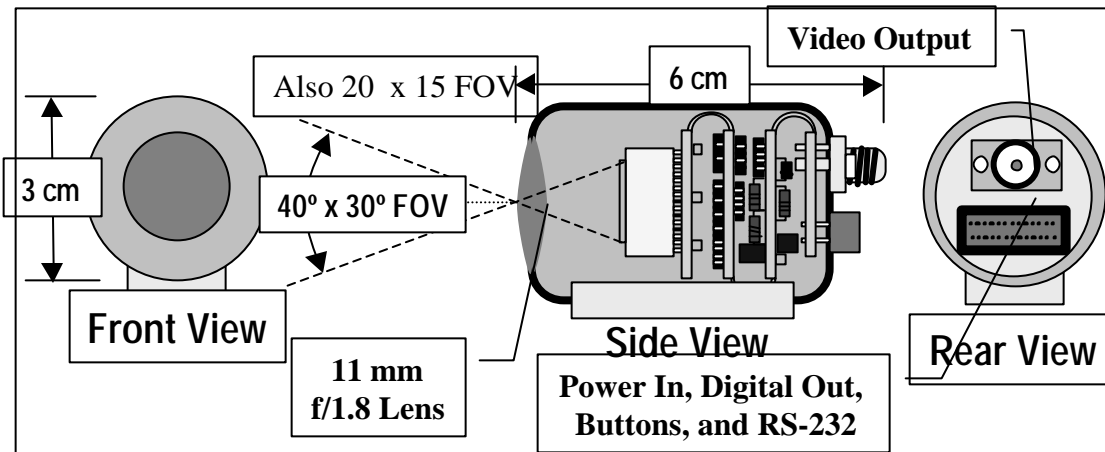## NVESD /AATD/AMCOM MOU to Develop an Integrated Sensor w/ Mini-UAV

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Challenges

- What Sensors at what Cost?
- Size, Weight, Power, Data Link Constraints
- Unstablized
- Fixed Pointing
- Sensor Range
- Motion effects on Imagery
- Measures of Effectiveness

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Miniature Low Cost Uncooled IR Camera Specification Summary and Design

Video Output

Also 20 x 15 FOV

6 cm

3 cm

40º x 30º FOV

Front View

11 mm
f/1.8 Lens

Side View

Power In, Digital Out, Buttons, and RS-232

Rear View

Design Mock-up

Design Goal: Ultra low cost $500 FLIR for day/night imaging
Applications: Mini-UAVs, Sensor Networks, APLA, UGS, Goggles

Specifications

- Total System Power = 540 mW @ 3.5V
- Total Weight (with optic) <70 g
- Radiometric Performance <70 mK
- Array size = 160x120
- Pitch = 50 um x 50 um
- Optics = f/1.8, Frame Rate = 30 Hz
- Operating temperature = -40º to 55ºC

Detection of Walking Man Target

FPA	Sensor Field of Regard/Range	
	40º FOV	15º FOV
160x120	FOR = 165m/ Range= 240m	190m/ 720m
320x240	330m/ 480m	380m/ 1440m

Target: Walking Man (0.75m/2.0º C), 90% Detection/0.5 cycles on target, Atmosphere: 80%/lm

"Alpha" camera (190g) development completed in FY99 and seven 40º FOV units delivered. 15º and 25º FOV versions available in FY00.

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Electron Bombarded Active Pixel Sensor (EBAPS)

- Video formats – B&W, NTSC or SXGA (1280 x 1024 pixels)
- Operating Band – EBAPS to 1 micron
  - Transfer Electron EBAPS to 1.5 micron
- Performance (NTSC) – 550 Horizontal TVL resolution at 10^{-1} Lux (Twilight)
  - 250 Horizontal TVL resolution at 10^{-3} Lux (Starlight)
- Performance (SXGA) – 1100 Horizontal TVL resolution at 10^{-1} Lux (Twilight)
  - 350 Horizontal TVL resolution at 10^{-3} Lux (Starlight)
- Camera Size – 1" diameter by 2" long, not including lens and battery
- Power requirement – 0.6 Watts
- Lens format – 2/3"
- Operating life   - 5000 hours at 10^{-1} Lux
- Other features – B&W daylight with intensifier off
  (350 TVL horizontal resolution at 10^{-1} Lux
  with NTSC display or 700 TVL horizontal
  resolution with SXGA display)
  - AGC, so an auto iris lens is not required

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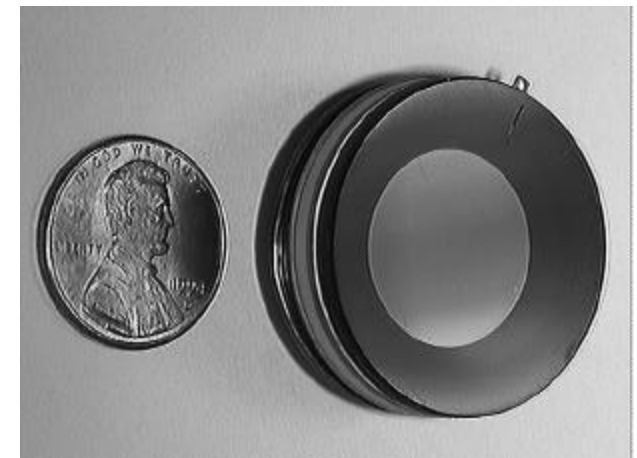
Initial Trends

- 15-25 degree FOV - Depends on situational awareness first, sensor resolution close second
- Altitude of 600 ft. AGL adequate for nominal operations. (Engine Noise effects operational altitude)
- Fixed Down look angle of 15-30 degrees
- Slow speed loiter (20 kts)
- Freeze Frame and Real Time display of imagery

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Near Term Tests Supporting Mini UAV Sensors

- Sensor FOV
- Sensor Pointing Angles
- Sensor Resolution Vs Altitude
- Sensor Dwell Time Vs Speed
- Power constraints
- Audible Noise, Aircraft Vibration
- Mosaics and Search Patterns
- Mini Pan and Tilt
- Cued Search and Search/Loiter patterns

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AeroVironment Pointer
Mini-UAV Work Horse Test Bed

Airframe Design

- Kevlar composite with foam core
- 9 foot wingspan, 6 feet from nose to end of tail boom
- ~180 cubic inches of payload space (batteries share payload space)
- 2 pound payload capacity
- 12 pound maximum liftoff weight (including 2 lb payload)
- Nose features a 1 inch diameter opening for forward camera or sensor visibility
- 2 man portable - 2 cases for wings and fuselage and ground control station case
- 28V non-conditioned and 12V conditioned electrical power available
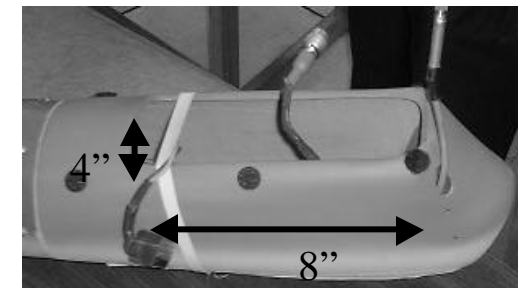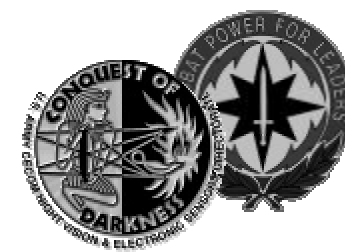- GPS guided ground based autopilot

Performance

- 300 watt electric motor driven propeller
- Cruise 22 knots, Stall 19 knots, Dash 44 knots
- 10 KM Range w/1.72Ghz RS-170 Video transmitter & 2 way data link
- Auto gyro-stabilized flight - Pilot commanded speed, climb, and heading control

Duration

- 15 minutes - Two NiMH rechargeable battery packs
- 30 minutes - Two NiCd rechargeable battery packs
- 60 minutes - Two Lithium non-rechargeable batteries

4"

8"

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Mini-Fixed Wing UAV
Sensor Schedule

MILESTONES	FY01	FY02	FY03	FY04	FY05	FY06
•Mission Technologies						
➤ Proof-of-Concept Uncooled IR	▲					
➤ AVS Technology	▲					
•Prescott						
➤ Proof-of Concept	▲					
➤ Uncooled IR	▲					
➤ Acoustic		▲				
➤ Acoustic + IR			▲			
➤ CMOS EBAPS				▲		
•Pointer						
➤ IR	▲					
➤ Acoustic	▲					
➤ IR + Acoustic			▲			
➤ CMOS EBAPS			▲			
➤ FOPEN LIDAR					▲	

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Mini UAV Payload Extensions

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Aided Target Recognition for TUAV
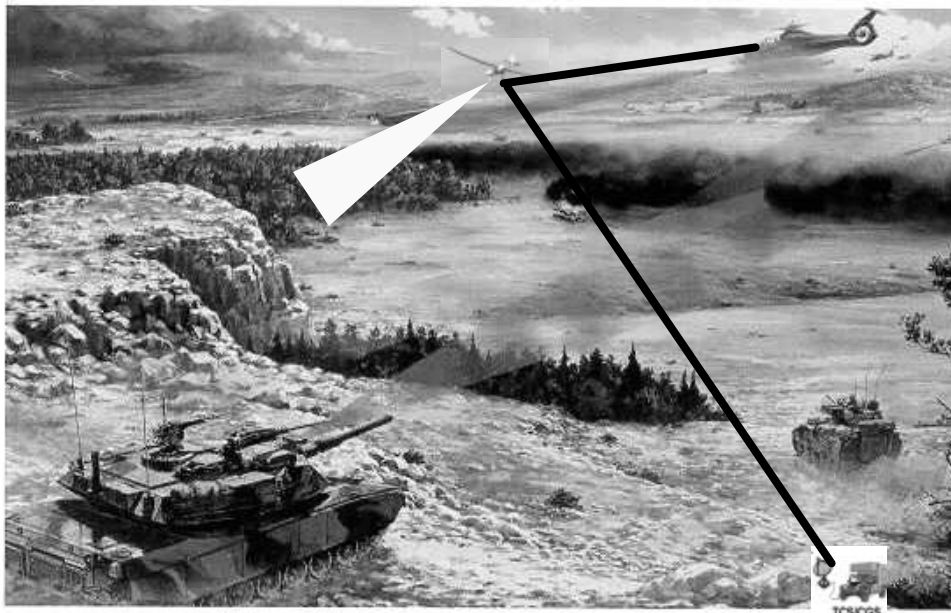
Objective

▷ **Demonstrate Comanche target cueing and detection algorithm for tactical level unmanned ariel vehicle to operate with either SAR or EOIR sensor payloads**

▷ **Increase mission effectiveness in brigade and below information dominance and targeting**

▷ **Demonstrate real-time reconnaissance and surveillance ATR to include target identification in SAR data**

Warfighter Payoffs

▷ **Positive, timely and reliable air to ground target detection and identification**

▷ **Ranges compatible with surveillance and reconnaissance requirements**

▷ **Maximize rotorcraft survivability and situational awareness**

▷ **Provides common software and open architecture for effective plug "n" play**

▷ **Provides "eyes forward" for brigade and below mission effectiveness**

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Short Path from Lab to Real-time HW
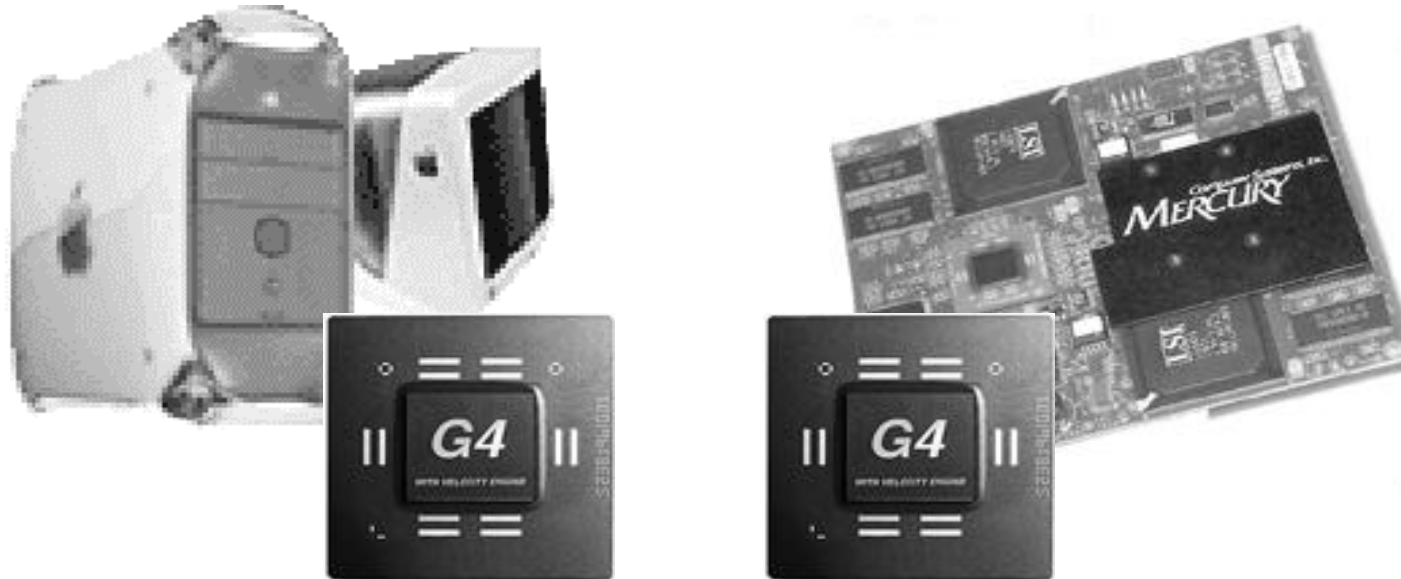
Development Hardware   =====>   Real-time Target Hardware

G4 Delivery Schedule:

- Motorola: 9/99
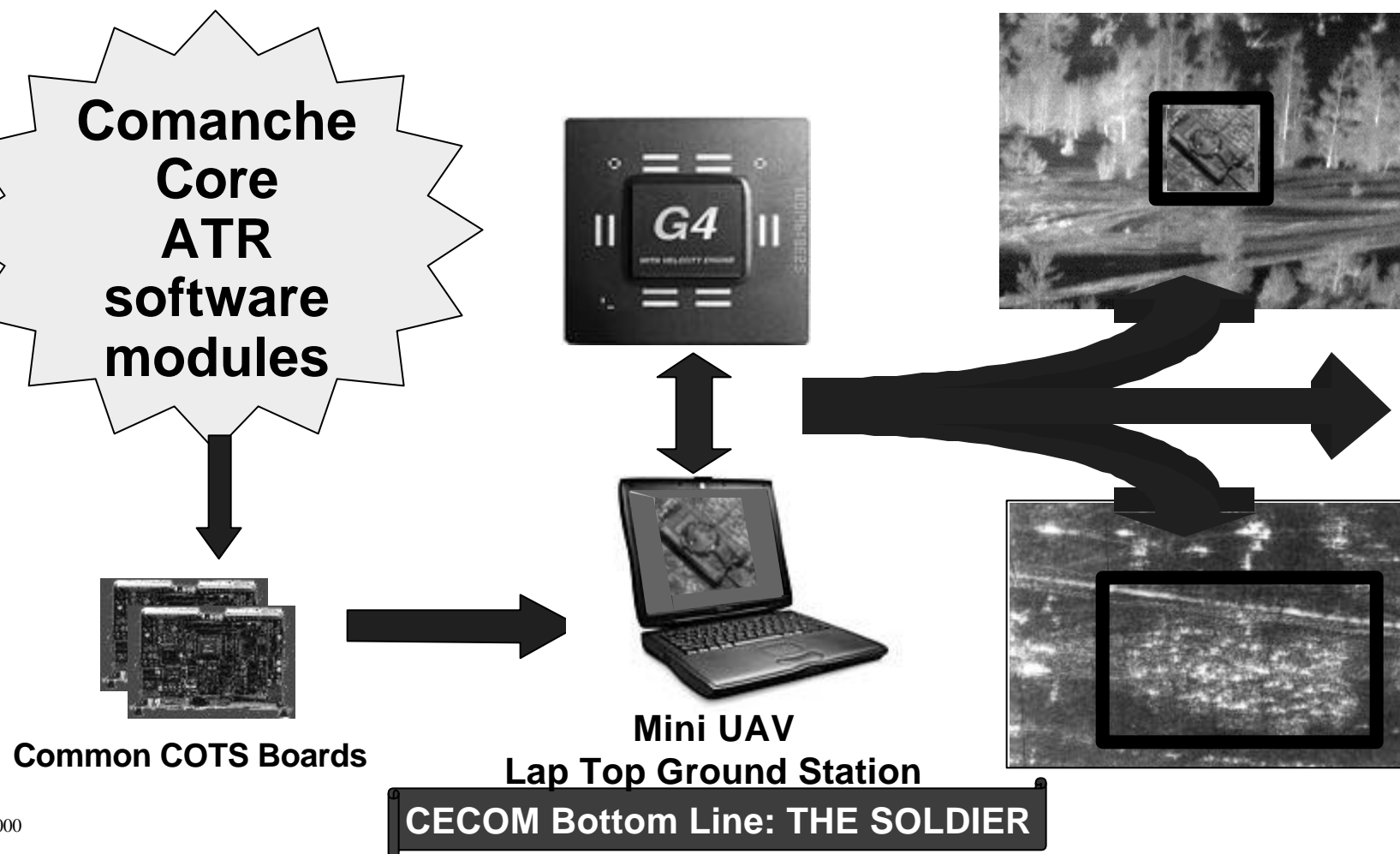- Apple: 11/99
- Mercury: 7/00 (6U VME quad boards using G4/P with G3/P as backup)

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Aided Approach Leverages Comanche/ TUAV to Provide Target Cueing for Mini UAV

- Leverage existing programs to integrate common ATR software modules into a Common COTS processor.

Comanche Core ATR software modules

G4

Common COTS Boards

Mini UAV Lap Top Ground Station

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Mini Unmanned Aerial   ***Vehicle (MUAV)***

Real-time control
of video sensor

Creation of large
area mosaics from
individual video
frames

Georeferencing of
target coordinates

Activity monitoring
within field
of regard

Multiple targets
tracked in
real-time

Battlefield

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AVS Technology

Precision Video Registration - Harris, U. Central Florida, Sarnoff

Photogrammetric registration of video to reference imagery for accurate geolocation

Goal: 2-10 meter accuracy, real time

Technologies
- Automatic registration
- Precision orthomosaics

Challenges
- Mission image - reference image variations: viewing angle, seasons, field of view
- Scene content, video quality

Metrics
- Registration accuracy (pixels and meters)
- % of frames registered
- Vs. scene content, video quality, mission - reference image variations

October '99 - Ft. AP Hill
- 1 Hz registration
- Precision Orthomosaics

Reference Data:
- 1 meter orthophoto
- DTED level 2

Activity Monitoring - SRI, University of Maryland

A taskable sentry for the video payload operator

Goal: Monitor multiple video streams at once

Technologies
- Activity templates, recognition
- Site surveillance

Challenges
- Viewing geometry variation
- Range of activities: incursion to complex interaction

Metrics
- Human detection and tracking: P(d), P(t)
- Site-model registration: accuracy
- Vs. levels of difficulty

Detected vehicle

Current camera footprint

Depot gate

Detected people

Priority alert

ROI for alert

Active Sub-task

Alert: people near woods
Looking for: people approaching gate
frame = 67

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October '99 - Ft. AP Hill
- Intruder detection and vehicle removal

Example of Mosaiced and Registered Imagery
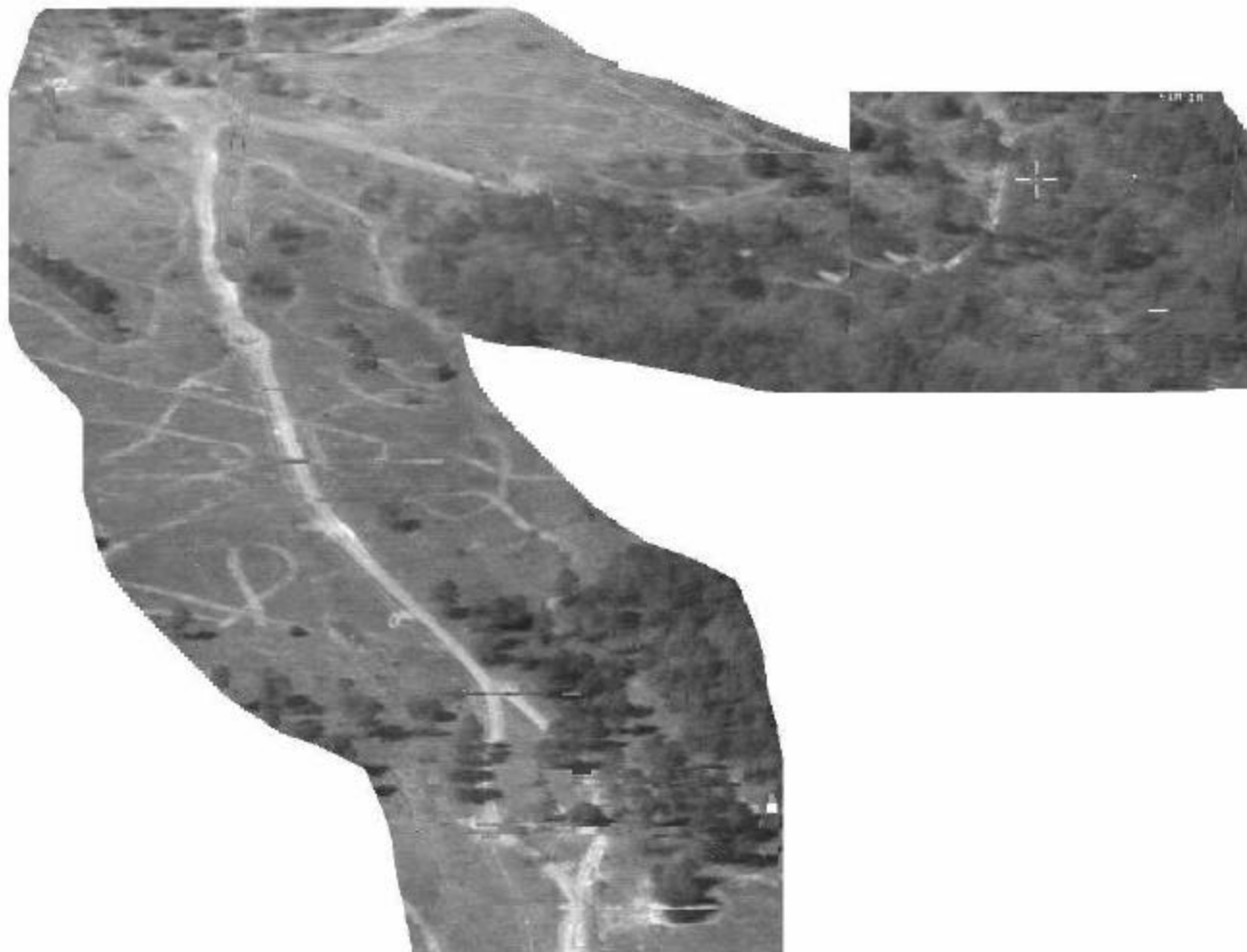
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Future Course for Mini UAV Leverage of VTOL UAV

Cypher	Dragon Warrior	Lift Augmented Ducted Fan (LADF)	LADF
6.2 ft. Diameter	4.7 ft. Diameter	2.2 ft. Diameter	9 in. Diameter
300 lbs Total Weight	200 lbs Total Weight	50 lbs Total Weight	3.2 lbs Total Weight
45 lbs Payload Capacity	25-35 lbs Payload Capacity	20 lbs Payload Capacity	.25 lbs Payload Capacity

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Conclusions

Mini UAVs with User friendly launch and recovery having day/night sensor packages will provide a critical capability to the Objective Force.

Provides Beyond Line of Sight situational awareness for targeting of long range weapons and conflict management

NVESD developing sensors, sensor technology, and processing to ensure potential of Mini UAV can be achieved

Critical to the Transformation of the Army (FCS)